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This study evaluated whether Special Forces (SF) soldiers training in garrison would meet nutrient intake recommendations using the available garrison dining facility. Dietary intakes were obtained by a visual estimation method and self-reported food records from 32 SF and 13 support (SUP) soldiers for 9 days. Total energy expenditure (TEE) was measured in 9 soldiers from each group using doubly labeled water. Mean (+ SD) TEE of SF (4099 + 740 kcal/day) was higher than SUP (3361 + 939 kcal/day) ($p < 0.01$). Energy intake (EI) did not differ between groups. Median EI for all soldiers was 3204 kcal/day. The nutrient intake goals of SF soldiers were not fully met by eating in the dining facility. Extending meal times and providing additional meals of "take out" foods may allow energy needs of SF soldiers (~4200 kcal/day) to be met, while reducing the reliance on potentially less nutritious outside foods.

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Adequacy of Garrison Feeding for Special Forces Soldiers during Training

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This study evaluated whether Special Forces (SF) soldiers training in garrison would meet nutrient intake recommendations using the available garrison dining facility. Dietary intakes were obtained by a visual estimation method and self-reported food records from 32 SF and 13 support soldiers for 9 days. Total energy expenditure (TEE) was measured in nine soldiers from each group using doubly labeled water. Mean (± SD) total energy expenditure of SF (4,099 ± 740 kcal/day) was higher than support soldiers (3,361 ± 939 kcal/day, $p < 0.01$). Energy intake did not differ between groups. Median energy intake for all soldiers was 3,204 kcal/day. The nutrient intake goals of SF soldiers were not fully met by eating in the dining facility. Extending meal times and providing additional meals or "take out" foods may allow energy needs of SF soldiers (~4,200 kcal/day) to be met, while reducing the reliance on potentially less nutritious outside foods.

Introduction

Special Forces (SF) soldiers are specially trained military personnel who use nonconventional means to achieve military, political, and economic objectives in hostile, denied, or politically sensitive areas.[1] Their missions are conducted during war and peacetime, with and without coordination with conventional forces.[1] These small units of soldiers are often required to be self-sufficient for extended periods of time.[2] Daily training is physically demanding, consisting of near-continuous physical work of variable intensity.[2] Although the daily average total energy expenditure (TEE) of SF soldiers training in garrison has not been quantified, U.S. Army Rangers, with similar training, had an average TEE of 4,500 kcal/day (239 kcal = 1 MJ) during garrison training and 5,200 kcal/day during field training.[3] Because of the high energy and nutritional demands of their training, it is important that SF soldiers maintain adequate dietary intakes while in garrison. An optimal diet in garrison can support the capacity to sustain highly demanding training. Equally important, when soldiers are adequately nourished before deployment, moderate energy deficits usually take 30 to 60 days to impair physical performance.[4,5] Soldiers in a nutritionally compromised state who are deployed for combat may suffer degraded performance and poor health more rapidly.

SF soldiers are typically senior in rank, married, and living in off-post housing. Thus, they eat many, if not most, of their meals at home or in commercial establishments. Given the variability of individual living situations, limited time to prepare and consume meals, and perhaps inadequate knowledge of proper food choices, the quality of SF diets may not be optimal. In fact, a nutrition knowledge survey revealed that many SF soldiers have limited knowledge of general and sports nutrition concepts.[6] The Special Operations Command was concerned that SF soldiers might not have nutritionally adequate diets. One possible strategy to ensure optimal nutritional "readiness" of SF soldiers could be to maintain greater control over their diet by directing them to use SF dining facilities. To determine the effectiveness of this strategy, this study was conducted to characterize the energy requirements of SF and support (SUP) personnel and to evaluate the adequacy of self-selected diets of soldiers eating in an SF dining facility using current, standard feeding operations.

Methods

Volunteers and Experimental Design

The volunteers were 32 SF A Team soldiers assigned to the 10th SF Group (Airborne), SFG (A), and 13 SUP soldiers attached to the SF unit. The SUP soldiers were studied to allow comparisons of the energy requirement of SF soldiers with that of soldiers with more typical Army jobs. The unit studied was conducting routine garrison training. SF training consisted of foreign language practice, mountain hiking with full load, rock climbing, urban warfare training, and small weapons handling. SUP soldiers participated in routine physical training, assembled equipment for SF use, drove vehicles to training sites, and performed administrative support functions. All volunteers were men because women are excluded from the SF. The investigators adhered to the policies for protection of human volunteers as prescribed in Army Regulation 70-25, and the research was conducted in adherence with the provisions of 45 CFR Part 46. Before data collection, all volunteers were briefed on the study objectives and their responsibilities and gave their written informed consent. All volunteers were asked to fill out a background survey giving such information as their age, rank, military occupational specialty, how often they used the dining facility, reasons for not using the dining facility more often, and

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The views, opinions, and/or findings in this report are those of the authors and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other official documentation. The investigators adhered to the policies for protection of human subjects as prescribed in Army Regulation 70-25, and the research was conducted in adherence with the provisions of 45 CFR Part 46. Citation of commercial organizations and trade names in this report does not constitute an official Department of the Army endorsement or approval of the products or services of these organizations.

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nutritional supplements they regularly consumed. A subgroup of 18 soldiers, 9 each from the SF and SUP groups, was administered doubly labeled water (DLW) to assess total energy expenditure (TEE) (see below). TEE of the subgroup and dietary intakes of all volunteers were assessed for 9 consecutive days that included 7 weekdays (days 1–2 and 5–9) and 2 weekend days (days 3 and 4). The data collection schedule is shown in Figure 1.

Volunteers were asked to continue their normal training patterns during the study. The volunteers ate at the SF dining facility during the week, but because the dining facility does not serve meals on Friday evenings or on weekends, they ate at home, restaurants, or from other outside sources for those meals. The SF soldiers worked or trained for approximately 8 to 10 hours per day during the week. The length of the SUP soldiers' workday was similar. Neither SF nor SUP soldiers performed formal military training or work on the weekends.

Body Height, Weight, and Composition

Standing height was measured at baseline to the nearest 0.1 cm using an anthropometer (Seritex, Carlstadt, NJ). Seminude (underwear and T-shirts) body weights were measured in the morning to the nearest 0.1 kg using a calibrated electronic battery-powered scale (model 6800; Cardinal Detecto, Webb City, MO). Body composition was determined for the subgroup of volunteers administered the DLW, with dual energy X-ray absorptiometry (DEXA) using the manufacturer's procedures and supplied algorithms (Total Body Analysis, Version 3.6, DEXA model DPX-IQ; Lunar Corporation, Madison, WI). Body weights and DEXA measurements were obtained on days 1 and 10.

TEE and Total Body Water (TBW)

TEE was assessed using DLW according to previously described procedures.[7] Briefly, volunteers reported to the test site on the morning of day 1 in a fasted state (~8 hours). They provided a urine and saliva sample before being administered the DLW, and they also provided two additional saliva samples at 3 and 4 hours after DLW administration. A standard absolute dose of 116.4 g of 10% $H_2{}^{18}O$ and 8.5 g of 99.9% of ^2H_2O (Isotec, Miamisburg, OH) was administered to all volunteers. The standard dose was based on approximately 0.23 g/kg estimated TBW of $H_2{}^{18}$ and 0.15 g/kg estimated TBW of ^2H_2O for an 80 kg reference man. About 50 mL of bottled water from a local source was also consumed after it was used to rinse the dose container. TBW was calculated using the ^{18}O enrichments obtained from the saliva samples taken before and 3 and 4 hours after ingesting the isotope tracers.[8] First-morning urine samples were collected on the following 9 days to measure isotope elimination. A final urine sample on the morning of day 10 was obtained to account for energy expended on the last measurement day (day 9). Isotope elimination rates for ^2H and ^{18}O were corrected for the changes in isotope abundances by measuring the elimination rates in three soldiers (two SF and one SUP) who were not administered the isotope tracers.[7] A metabolic fuel quotient of 0.85 was assumed, based on the finding of stable body fat stores and consumption of a typical western diet.[9] Isotope analyses were performed according to published methods.[7]

Dietary Intake

A visual estimation method[10] was used to quantify the intake of foods and beverages in the dining facility. Data collectors were trained immediately before the study to ensure consistency within and between data collectors. The accuracy of this visual estimation method is comparable to the weighing method for estimating individual dietary intakes.[11] After obtaining food from the serving area and before eating, a volunteer presented his tray to a data collector, who recorded the food items present and estimated the amounts by visual comparisons to weighed standards of the same foods. After the meal, the volunteer returned to the same data collector, who estimated and recorded the quantity of uneaten food using the same visual comparison method. Intake of each food item was calculated as the differ-

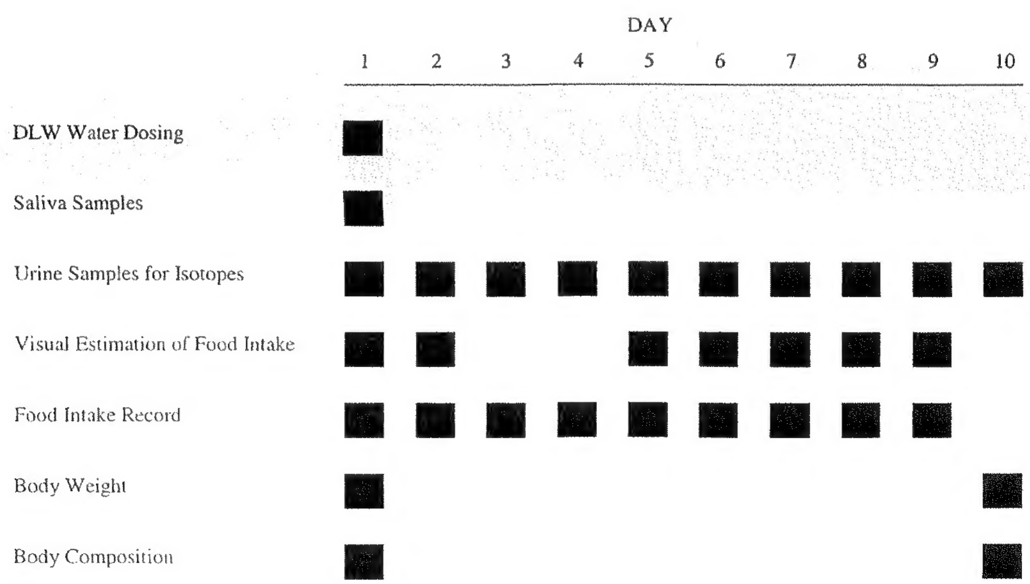

Fig. 1. Schedule of tests.

ence between amount taken and amount returned. Volunteers recorded all food consumed outside the dining facility, including dietary supplements and weekend consumption when the dining facility was closed. Dietary data collectors reviewed the food records with volunteers daily, except during the weekend, to confirm complete and accurate entries. Days for which a volunteer failed to provide complete intake data, which occurred approximately 7% of the time, were not included in the calculation of that volunteer's mean intake. Dietary data collected from five SF volunteers (two with DLW data) were not used in the nutrient intake analyses because of incomplete data.

Recipe specialists recorded the ingredients and amounts used in preparation of foods served in the dining facility, so that accurate computerized estimates of the nutrient composition of recipe items could be calculated. Dietary intake data were analyzed using the Statistical Package for the Social Sciences (SPSS) software (SPSS, Chicago, IL) and food composition data from Moore's Extended Nutrient Data Base (Menu). The Menu database at the time of the study was derived from the U.S. Department of Agriculture's Nutrient Database for Standard Reference, version 13[12] and the 1994–1996 U.S. Department of Agriculture Database for the Continuing Survey of Food Intakes by Individuals.[13]

Statistics

Descriptive statistics (means and SD) were computed and individual group differences were determined by independent t tests. Typical of intake data, mean intakes of most nutrients were not normally distributed; therefore, these data are presented as medians with interquartile ranges. Nonparametric methods were used to determine group intake differences (e.g., Wilcoxon signed rank test). A one sample t test was used to determine whether the TEE of SF soldiers exceeded the military dietary reference intake (MDRI) for energy for moderate activity (3,250 kcal/day).[14,15] The MDRIs are recommended reference values for military personnel. Multivariate analyses of variance were used to determine group differences for energy intake (EI), nutrient intakes, and energy and nutrient intakes by body weight. Repeated measures analyses of variance were used to determine pre- and poststudy differences for body weight and body fat by group. The level of significance was set at $p \leq 0.05$ for all tests.

Results

SF soldiers were older ($p < 0.001$) and weighed more than SUP soldiers ($p < 0.02$; Table I). Neither group's body weight changed significantly during the study. There were no differences in percentage of body fat between groups or over time. The TEE of SF soldiers was greater ($p < 0.01$) than SUP soldiers (Table I). The energy requirement of SF soldiers (4,099 kcal/day) was greater ($p < 0.009$) than the general-use MDRI for moderate activity (3,250 kcal/day).[14,15] Eighty-nine percent of soldiers in this SF sample unit had TEEs exceeding the general-use MDRI. In contrast, the average energy requirement of SUP soldiers (3,136 kcal/day) was not significantly different than the 3,250 kcal/day energy allowance for moderately active men.

Attendance figures for the dining facility meals show that, on average, SF soldiers did not eat at the dining facility as frequently as SUP soldiers (Table II). A total of 19 meals were served at the dining facility during the study. The SF soldiers, compared with SUP, had lower attendance at 10 meals, higher attendance at 5 meals, and approximately equal attendance at 4 meals. Not counting breakfast on day 1, which was missed by many volunteers because of testing requirements, attendance at meals averaged 80% for SF soldiers and 84% for SUP soldiers. Both groups missed an average of four meals per week. From the background questionnaire, 56% of SF (15 of 27) and 31% of SUP (4 of 13) soldiers cited scheduling conflicts as the principal reason for not eating in the dining facility.

The majority of energy consumed during the weekdays came from the dining facility (Table III). Considering only the days when the volunteers had the opportunity to attend three meals, days 5 to 8 of the study, there was no significant group difference in the proportion of total EI obtained from the dining facility. During these days, the SF consumed 73% (2,435 ± 534 kcal/day) of their EI in the dining facility compared with 77% (2,652 ± 939 kcal/day) by the SUP. The mean dining facility intake of 2,505 ± 688 kcal/day for all volunteers for these 4 days was significantly higher ($p < 0.05$) than those for the other three weekdays (days 1, 2, and 9), during which the volunteers consumed an average 1,796 ± 604 kcal/day in the dining facility, which was 60% of their total EI. These days with the lower intakes included the two Fridays (no dinner) and the first day of the study.

There were no differences between SF and SUP soldiers in

TABLE I

PHYSICAL CHARACTERISTICS AND ENERGY EXPENDITURE MEASUREMENTS FOR SF AND SUP

Measure	SF	n	SUP	n	p
Age (years)	33 ± 4	32	21 ± 2	13	0.001
Height (cm)	179 ± 7	31	175 ± 6	13	NS
Prestudy body weight (kg)	83.9 ± 12.8	27	73.7 ± 7.2	12	0.02
Poststudy body weight (kg)	83.8 ± 12.8	27	74.3 ± 7.5	12	0.007
Prestudy body fat (%)	19.3 ± 4.1	12	19.2 ± 6.4	11	NS
Poststudy body fat (%)	19.3 ± 3.8	12	19.6 ± 6.3	11	NS
Total body water (L)	47.9 ± 2.8	9	42.4 ± 3.9	9	0.002
TEE (kcal/day)	4,099 ± 740	9	3,136 ± 652	9	0.01
TEE/kg of body weight (kcal · kg body weight^{-1} · day^{-1}	50 ± 13	9	42 ± 6	9	0.07

Values are means ± SD.

TABLE II

PERCENTAGE OF ALL VOLUNTEERS ATTENDING MEALS IN THE DINING FACILITY

		Day 1 Thursday	Day 2 Friday	Day 3 Saturday	Day 4 Sunday	Day 5 Monday	Day 6 Tuesday	Day 7 Wednesday	Day 8 Thursday	Day 9 Friday
	Valid n^a	32	32	31	31	31	31	30	30	29
SF										
Breakfast	% of n	34	91	–	–	84	87	87	83	76
Lunch	% of n	88	84	–	–	87	77	73	80	72
Dinner	% of n	78	–	–	–	77	65	70	80	–
	Valid n	13	13	13	13	13	13	13	13	13
SUP										
Breakfast	% of n	23	92	–	–	92	77	69	85	77
Lunch	% of n	100	92	–	–	92	92	85	85	69
Dinner	% of n	92	–	–	–	100	92	54	69	–

[a] Valid n is the number of volunteers with complete dietary data for the day.

TABLE III

GROUP MEAN ENERGY INTAKE (KILOCALORIES PER DAY) BY FOOD SOURCE BY DAY

	Day 1 Thursday	Day 2 Friday	Day 3 Saturday	Day 4 Sunday	Day 5 Monday	Day 6 Tuesday	Day 7 Wednesday	Day 8 Thursday	Day 9 Friday
Valid n^a	26	25	26	27	27	27	25	25	22
SF									
Dining facility	2,124 ± 874	1,748 ± 681	–	–	2,690 ± 876	1,983 ± 740	2,370 ± 865	2,669 ± 835	1,490 ± 717
Outside foods	779 ± 816	1,391 ± 950	3,474 ± 1,611	2,725 ± 966	664 ± 481	1,102 ± 812	885 ± 721	963 ± 970	1,774 ± 1,041
Total	2,904 ± 1,028	3,139 ± 965	3,474 ± 1,610	2,725 ± 966	3,353 ± 752	3,085 ± 663	3,254 ± 733	3,632 ± 795	3,264 ± 983
Valid n	13	12	12	13	13	13	13	12	12
SUP									
Dining facility	2,256 ± 659	1,906 ± 490	–	–	3,001 ± 840	2,625 ± 1,058	2,099 ± 1,220	2,762 ± 1,427	1,449 ± 760
Outside foods	489 ± 629	1,517 ± 803	3,030 ± 950	2,493 ± 1,127	439 ± 491	444 ± 634	1,205 ± 1,123	1,080 ± 1,258	2,736 ± 1,066
Total	2,746 ± 803	3,423 ± 855	3,020 ± 950	2,493 ± 1,127	3,440 ± 650	3,069 ± 794	3,303 ± 833	3,843 ± 1,150	4,185 ± 1,374

Values are means ± SD.

[a] Valid n is the number of volunteers with complete dietary data for the day.

absolute total energy or nutrient intakes, percentage of EI from the energy-yielding nutrients, or intake of the energy-yielding nutrients relative to body weight. Therefore, dietary intake data for the groups were combined to assess overall nutrient intakes and to compare the quality of food selections from the dining facility with that from outside sources. Table IV shows the average absolute nutrient intakes for the overall study, plus the separate weekday and weekend intakes. On the days the dining facility served meals, i.e., the weekdays, the dining facility provided 71% of the total EI and significantly greater proportions of many important nutrients (e.g., 71% carbohydrate, 77% protein, 87% β-carotene, 87% vitamin C, and 81% vitamin A), but also of total fat (74%), saturated fat (72%), and cholesterol (82%). Table V shows the intakes of the energy-yielding nutrients expressed as the proportion of total EI and intakes relative to body weight. As a percentage of total energy, food selections in the dining facility were significantly higher in protein and fat (16% and 38% of energy, respectively) than outside foods reported for weekdays (11% protein and 31% fat) and for weekends (15% protein and 32% fat). Intakes in the dining facility were also higher in fat (38% of energy) and saturated fat (12% of energy) than recommended (≤30% and ≤10%, respectively).[18]

Table VI outlines the comparisons of average daily nutrient intakes with reference intake values. Most soldiers met or exceeded the estimated average requirement for most nutrients. Important exceptions were vitamin E, folate, and magnesium. Furthermore, significant proportions of the soldiers did not attain their individual intake goals (MDRI, recommended dietary allowances, or adequate intakes) for several other nutrients including carbohydrate, dietary fiber, vitamin A, calcium, potassium, and sodium. The proportional intake of fat was high, whether compared with the Dietary Guidelines (i.e., ≤30% of energy from fat), which is the basis of the guideline in AR 40-25,[15] or the recently established acceptable macronutrient distribution range (20%–35% of energy from fat) for healthy diets.[21] Eighty-five percent of soldiers had diets with more than 30% of energy from fat (see Table VI), whereas 45% did not meet the more lenient 35% goal. Mean intake of saturated fat was greater ($p < 0.0002$) than the general guideline for 10% or less of total EI to come from saturated fat. Twenty-seven soldiers (68%) exceeded this recommendation.

Discussion

Because SF soldiers may experience nutritional deficits when deployed, it is essential that they maintain optimal nutrition in garrison to be prepared for their next deployment. Most SF

TABLE IV

ENERGY AND NUTRIENT INTAKES OF SF AND SUP COMBINED (N = 40)

	Overall Study	Weekday Days		Weekend Days
	Average Daily Intake[a]	Average Daily Intake[a]	Percentage from Dining Facility	Average Daily Intake[a]
Energy (kcal)	3,204 (2,838–3,676)	3,334 (2,934–3,709)	71 (60–78)	2,864 (2,257–3,433)[b]
Carbohydrate (g)	387 (346–471)	405 (360–484)	71 (56–78)	341 (230–413)[b]
Protein (g)	111 (102–129)	119 (107–130)	77 (65–82)[c]	105 (74–137)
Fat (g)	120 (106–138)	124 (111–146)	74 (63–82)[c]	105 (76–127)[b]
Saturated fat (g)	38.5 (34.3–45.7)	39.9 (35.3–47.8)	72 (61–81)[c]	32.8 (27.0–46.5)
Monounsaturated fat (g)	43.8 (40.5–51.9)	46.0 (40.9–54.3)	73 (61–81)[c]	39.1 (28.1–47.7)[b]
Polyunsaturated fat (g)	26.1 (20.6–30.8)	29.8 (22.5–34.3)	78 (69–85)[c]	19.2 (11.9–23.0)[b]
Alcohol (g)	7.9 (0.1–21.1)	3.7 (0.0–14.7)	NA	3.7 (0.0–45.0)
Dietary fiber (g)	19 (15–22)	20 (17–22)	72 (61–80)[c]	13 (9–20)[b,d]
Cholesterol (mg)	477 (391–561)	517 (407–640)	82 (75–87)[c]	336 (201–530)[b,d]
Vitamin A (μgRE)	946 (804–1,445)	1,085 (853–1,439)	81 (63–89)[c]	627 (298–1,244)[b,d]
β-Carotene (μgRE)	352 (257–697)	395 (280–774)	87 (65–94)[c]	171 (102–282)[b,d]
Vitamin E (mg)	10.1 (8.4–12.7)	10.9 (9.2–14.0)	78 (57–86)	9.1 (6.3–14.4)[b,d]
Vitamin C (mg)	197 (133–277)	240 (159–292)	87 (66–94)[c]	66 (37–224)[b,d]
Thiamin (mg)	2.24 (1.99–2.93)	2.36 (2.11–2.91)	75 (58–83)[c]	1.89 (1.25–3.04)
Riboflavin (mg)	2.58 (2.30–3.67)	2.74 (2.42–3.39)	73 (57–83)	2.27 (1.58–3.46)
Niacin (mg)	32.1 (24.8–36.8)	30.4 (25.7–36.0)	69 (49–79)	32.5 (20.3–48.2)[e]
Vitamin B6 (mg)	2.46 (2.17–2.93)	2.53 (2.34–3.04)	69 (55–79)	2.35 (1.39–3.78)
Folate (μg)	402 (322–579)	416 (356–520)	69 (58–82)	258 (177–585)[b,d]
Vitamin B_{12} (μg)	5.86 (5.09–7.78)	6.17 (4.92–8.56)	74 (55–82)	6.06 (3.66–9.78)
Calcium (mg)	1,065 (952–1,236)	1,141 (993–1,378)	72 (62–84)[c]	844 (603–1,251)[b,d]
Iron (mg)	19.3 (16.6–22.9)	20.1 (17.1–23.6)	70 (51–79)	17.2 (12.9–28.2)
Magnesium (mg)	341 (306–409)	372 (321–422)	66 (56–77)	299 (223–390)[d,e]
Phosphorus (mg)	1,716 (1,606–1,939)	1,856 (1,709–2,149)	73 (61–83)[c]	1,430 (1,185–1,911)[b,d]
Potassium (mg)	3,844 (3,154–4,271)	3,973 (3,496–4,802)	75 (68–81)[c]	2,750 (2,148–3,775)[b,d]
Sodium (mg)	4,291 (3,646–5,149)	4,548 (3,985–5,712)	77 (69–85)[c]	3,080 (2,495–4,410)[b,d]
Zinc (mg)	16.3 (14.1–20.7)	16.9 (14.3–20.6)	71 (50–80)	16.8 (12.1–21.7)[e]
Copper (mg)	1.7 (1.5–2.1)	1.8 (1.6–2.3)	68 (48–78)	1.3 (1.1–2.2)[b,d]
No. of days[f]	8.57 ± 0.7	6.63 ± 0.7		1.95 ± 0.22

[a] Median (25th–75th percentile). NA, Not applicable.
[b] Absolute weekend intake less than weekday intake ($p < 0.05$, Wilcoxon signed rank test for paired data).
[c] Different from percent total energy from dining facility ($p < 0.05$, Wilcoxon signed ranks test for paired data).
[d] Nutrient density (intake/1,000 kcal) of weekend intake less than weekday intake (data not presented) ($p < 0.05$, Wilcoxon signed rank test for paired data).
[e] Nutrient density (intake/1,000 kcal) of weekend intake greater than weekday intake (data not presented) ($p < 0.05$, Wilcoxon signed rank test for paired data).
[f] Mean ± SD.

soldiers live off-post and consume most of their meals at home or in commercial establishments. This results in little control of the nutritional readiness of these elite troops. This study characterized the energy requirements of SF and SUP soldiers and examined the adequacy of self-selected diets of these soldiers who were asked to eat all of their weekday meals in the SF dining facility. It was hypothesized that maximizing use of the dining facility would ensure that the energy and nutrient needs of these specially trained warfighters are met.

The energy expenditure data confirms that energy requirements of SF soldiers training in garrison are high. The average TEE of 4,099 kcal/day or 50 kcal/kg body weight^{-1} · day^{-1} measured in this study exceeds the energy allowance for moderate activity (3,250 kcal/day) specified in the MDRI table in AR 40-25, the Army Regulation governing nutritional allowance.[14,15] The MDRI values are quantitative estimates of nutrient intake goals to be used in planning diets for healthy military populations and represent the needs of a 79-kg reference military man and a 62-kg reference woman.[15] For male military personnel doing heavy work or involved in prolonged, vigorous physical training, the MDRI is 3,950 kcal/day, whereas for those doing exceptionally heavy activity, the energy allowance is 4,600 kcal/day.[15] The MDRI energy allowance for men with heavy levels of activity is based on an estimated average energy expenditure of 50 kcal/kg body weight^{-1} · day^{-1},[15] the same as that found for the SF soldiers assessed with DLW. One-third of these SF soldiers expended more than 58 kcal/kg body weight^{-1} · day^{-1}, defined as exceptionally heavy physical activity levels.[15] Using the mean TEE and average body weight of all the SF soldiers in the study, 84 kg, rather than the slightly lighter subgroup of subjects assessed with DLW (82 kg), the energy allowance for SF should be approximately 4,200 kcal/day. Energy needs may be even higher if soldiers need to regain weight lost during deployments. To meet energy requirements of SF, their garrison dining facility would have to plan menus with an average energy provision of at least 4,200 kcal/day.

TABLE V

ENERGY-YIELDING NUTRIENT INTAKES ADJUSTED FOR ENERGY AND BODY MASS WITH GROUPS COMBINED (N = 40)

		Weekday Days			
Nutrient (Unit)	All Days	Total	Dining Facility	Outside Foods	Weekend Days
		Percent Total Energy[a]			
Carbohydrate	48 (44–53)	48 (44–53)	47 (42–51)	53 (42–57)	49 (41–54)
Protein	14 (13–16)	14 (13–16)	16 (15–18)	11 (9–15)[b]	15 (13–17)
Fat	34 (32–39)	35 (31–39)	38 (33–42)	31 (24–36)[b]	32 (28–37)[c]
Alcohol	1.8 (0–4.8)	1.0 (0–3.9)	NA	3.2 (0–12.2)[d]	0.8 (0–9.9)[e]
Saturated fat	11 (10–13)	11 (10–13)	12 (10–13)	11 (9–12)	11 (9–14)
		Per kg Body Mass[a]			
Energy (kcal)	41.8 (35.4–43.6)	44.0 (34.7–464)	–	–	36.3 (28.4–43.5)[c]
Carbohydrate (g)	5.0 (4.2–5.9)	5.1 (4.4–6.0)	–	–	4.4 (3.1–5.2)[c]
Protein (g)	1.4 (1.3–1.7)	1.5 (1.3–1.6)	–	–	1.4 (1.0–1.7)

[a] Median (25th–75th percentile). NA, Not applicable.
[b] Outside food intake lower than dining facility intake ($p < 0.05$, Wilcoxon signed rank test for paired data).
[c] Weekend intake less than weekday intake ($p < 0.05$, Wilcoxon signed rank test for paired data).
[d] Outside food intake more than dining facility intake ($p < 0.05$, Wilcoxon signed rank test for paired data).
[e] Weekend intake greater than weekday intake ($p < 0.05$, Wilcoxon signed rank test for paired data).

TABLE VI

NUMBER AND PROPORTION OF SOLDIERS (*N* = 40) WITH NUTRIENT INTAKES NOT MEETING REFERENCE VALUES

		Estimated Average Requirement			Individual Intake Goal		
			Not Met			Not Met	
Nutrient (unit)	Average Daily Intake[a]	Value	n	%	Criterion	n	%
Carbohydrate (g/kg body weight)	5.0 (4.2–5.9)	–			5–7[b]	19	48
Protein (g/kg body weight)	1.4 (1.3–1.7)	0.66	0	0	1.15[c]	4	10
Fat (percent total energy)	34 (32–39)	–	NA		≤30[d]	34	85
Saturated Fat (percent energy)	11 (10–13)	–	NA		≤10[d]	27	68
Alcohol (g)	7.9 (0.1–21.1)	–	NA		≤30[e]	5	12
Dietary fiber (g)	19 (15–22)	–	NA		38[f]	40	100
Cholesterol (mg)	477 (391–561)	–	NA		≤300[d]	38	95
Vitamin A (μgRE)	946 (804–1,445)	–	NA		1,000[g]	12	55
Vitamin E (mg α-tocopherol)	10.1 (8.4–12.7)	12	29	72	15[h]	32	80
Vitamin C (mg)	197 (133–277)	75 110	0	0	90 125[i]	2	5
Folate (μg)	402 (322–579)	320	9	22	400[j]	20	50
Calcium (mg)	1,065 (952–1,236)	–	NA		1,000[k]	15	38
Magnesium (mg)	341 (306–409)	330 350	18	45	400 420[l]	32	80
Potassium (mg/kg body weight)	46 (42–55)	–	NA		40[g]	8	20
Sodium (mg/1,000 kcal)	1,347 (1,219–1,502)	–	NA		≥1,400[g]	29	72
					≤1,700[g]	4	10

[a] Median with interquartile range in parentheses. NA, Not applicable.
[b] Sports nutrition guideline for support of general physical training.[17]
[c] MDRI in AR 40-25.[14,15] Value is the mid-point of the MDRI range, which is an appropriate intake goal for typical, physically active military personnel.
[d] Dietary Guidelines for Americans, 2000.[18]
[e] Dietary Guidelines for Americans, 2000.[18] Criterion value equal to two alcoholic drinks.
[f] Adequate Intake Dietary Reference Intake, 2002.[16]
[g] Military Dietary Reference Intake in AR 40-25.[14,15]
[h] Recommended Dietary Allowance Dietary Reference Intake, 2000.[19]
[i] Recommended Dietary Allowance Dietary Reference Intake, 2000.[19] Higher value is reference value for smokers.
[j] Recommended Dietary Allowance Dietary Reference Intake, 1998.[20]
[k] Adequate Intake Dietary Reference Intake, 1997.[21]
[l] Recommended Dietary Allowance Dietary Reference Intake, 1997.[21] Higher value is reference value for men older than 30 years.

Achieving an EI of 4,200 kcal/day within the standard food service provision of three meals per day would require consumption of almost 1,400 kcal per meal. During the current study, mean EI from breakfast, lunch, or dinner was never more than 1,100 kcal/meal, suggesting that it is unrealistic to expect routine consumption of 1,400-kcal meals. On the 4 days (days 5–8) that most soldiers had the opportunity to eat three meals at the dining facility, they obtained approximately 900 kcal/day from outside foods (i.e., additional meals or snacks from sources other than the dining facility). The contribution of outside foods

in meeting the daily energy requirement is substantial. The caloric density of intakes in the dining facility was sufficiently high, as indicated by the proportion of energy from fat (38%). Therefore, to increase EI from the dining facility would require more than three meals per day or between meal snacks. Most military dining facilities are not designed, staffed, or resourced to provide this type of extended meal service.

During this study, the dining facility schedule did not always coincide with the SF training schedule. Soldiers often arrived late and rushed to complete eating or were forced to miss meals entirely because the facility was only open for approximately 1.5 hours per meal at set times each day. In addition, SF soldiers can lose valuable training time commuting from remote training sites to the dining facility. One strategy could be expanding the provision of "take out" meals and snack foods to supplement energy and nutrient intakes. Another solution to augment EI might be extending the meal hours at dining facilities to increase accessibility, and, in turn, patronage. Providing meals on Friday evenings and weekends, or serving between-meal snacks in the dining facility also could help meet the training schedules of SF soldiers. Increasing use of the dining facility could better ensure soldiers select high-quality, nutrient-dense foods and beverages. Navy SEAL trainees were able to consume over 5,000 kcal/day and maintain energy balance during continuous "Hell Week" training because of the provision of frequent meals (four meals a day) with a variety of food choices.[22] Providing supplemental carbohydrate/sports beverages is another potential solution that was shown to increase energy and carbohydrate intake of Rangers training in garrison.[23]

Measured EIs of the SF and SUP soldiers were comparable, even though the energy requirements of SF soldiers were greater. Because SF soldiers in this study had insignificant changes in body weight and body composition, they must have met their energy requirements. The discrepancy between TEE and EI is likely due to unreported food intake from outside sources. The visually estimated intake data from the dining facility is likely quite accurate.[11] Although dietary intake in the dining facility was well documented by investigators, food and beverages consumed outside of the dining facility were self-reported. Previous research has shown that self-reported dietary intake underestimates EI 8 to 30%.[24]

Previous studies have found that those individuals who underreport compared with valid reporters tend to report consuming healthier diets with regard to fat, protein, sugar, alcohol, and some micronutrients.[25,26] The foods most often underreported tend to be foods seen as unhealthy (e.g., sweets, savory snacks, some meat mixtures, soft drinks, fat-type spreads, and condiments). Therefore, the nutrient density of outside foods in this study is likely no better than reported, and perhaps substantially worse. The comparison of the nutrient densities of the weekday and weekend diets revealed that, in general, the weekend food choices, which were all outside foods, were of lesser nutritional quality than those made on the weekdays. Thus, the likely greater contribution of outside foods toward total dietary intakes is unlikely to remove the high prevalence of marginal nutrient intakes found here. The apparently high prevalence of soldiers with nutrient intakes less than recommended intake goals suggests that generous energy intakes cannot be counted on to compensate for poor dietary quality. That fat intake in the dining facility was higher than recommended does not indicate that the overall menu was high in fat; rather, that the soldiers chose more of the high-fat foods and fewer of the high complex carbohydrate foods. Because fat foods contain over twice the energy per unit weight as carbohydrate foods, selecting fat will increase caloric intake. When the soldiers ate in the dining facility, their food choices, for the most part, were more nutritious than outside foods. This observation highlights the importance of providing soldiers with nutritional guidance and education, regardless of whether they eat in a garrison dining facility or elsewhere.

In summary, maximizing the use of the SF dining facility within the current feeding structure did not ensure adequate nutrient intakes. The energy allowance for SF soldiers is greater than the general value for moderately active servicemen in the MDRI table in AR 40-25[15] because of their greater body weight and higher physical activity level than the average male soldier. Consequently, SF foodservice must be able to provide approximately an additional 900 kcal $\cdot$ day^{-1} $\cdot$ soldier^{-1}, to support average total EI of 4,200 kcal/day. It is unlikely such a high energy intake can be achieved with a three-meal per day feeding plan. Extending meal hours at the dining facility, incorporating a fourth daily meal option, and/or providing nutritious "take out" foods are potential strategies dining facilities could adopt to better support the nutritional needs of SF personnel in garrison. Nutritional guidance is also needed to help these soldiers make the best food choices whether in or outside of the dining facility.

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References

1. Moloff AL, Bettencourt B: The Special Forces medic: unique training for a unique mission. Milit Med 1992; 2: 74–6.
2. Bohrer D: America's Special Forces. St. Paul, MN, MBI Publishing Company, 2002.
3. Tharion WJ, Warber JP, Hoyt RW, DeLany JP: Energy requirements of Rangers in garrison vs. in the field. FASEB J 1998; 12: A204.
4. Friedl KE: When does energy deficit affect soldier performance? In: Not Eating Enough, pp 253–83. Edited by Marriott BM. Washington, DC, National Academy Press, 1995.
5. Lieberman HR, Askew EW, Hoyt RW, Shukitt-Hale B, Sharp MA: Effects of 30 days of undernutrition on plasma neurotransmitter precursors, other amino acids, and behavior. J Nutr Biochem 1997; 8: 119–26.
6. Bovill ME, Tharion WJ, Lieberman HR: Nutrition knowledge and supplement use among elite U.S. Army soldiers. Milit Med 2003; 168: 997–1000.
7. DeLany JP, Schoeller DA, Hoyt RW, Askew EW, Sharp MA: Field use of $D_2{}^{18}O$ to measure energy expenditure of soldiers at different energy intakes. J Appl Physiol 1989; 67: 1922–9.
8. Schoeller DA, van Santen E, Peterson DW, Deitz W, Jaspan J, Klein PD: Total body water measurement in humans with ^{18}O- and ^{2}H-labeled water. Am J Clin Nutr 1980; 33: 2686–93.
9. Montoye HJ, Kemper HCG, Saris WHM, Washburn RA: Measuring Physical Activity and Energy Expenditure. Champaign, IL, Human Kinetics, 1996.
10. Rose MS, Buchbinder JC, Dugan TB, Szeto EG, Allegretto JD, Rose RW, Carlson DE, Sammonds KW, Schnakenberg DD: Determination of Nutrient Intakes by a Modified Visual Estimation Method and Computerized Nutritional Analysis for Dietary Assessments. Technical Report T6–88. Natick, MA, U.S. Army Research

Institute of Environmental Medicine, September 1987.

11. Schnakenberg D, Carlson D, Deems S, Popper R, Hirsch E: Validation of a visual observation method for nutritional evaluation of food service systems for a military population. Fed Proc 1987; 46: 875.
12. U.S. Department of Agriculture: USDA Nutrient Database for Standard Reference, Release 13. Washington, DC, Human Nutrition Information Service, 2000.
13. U.S. Department of Agriculture Agricultural Research Service: 1994–1996 Continuing Survey of Food Intakes by Individuals and 1994–1996 Diet Health Knowledge Survey (CSFII/DHKS). Bethesda, MD, Agricultural Research Service, 1998.
14. Baker-Fulco CJ, Bathalon GP, Bovill ME, Lieberman HR: Military Dietary Reference Intakes: Rationale for Tabled Values. Technical Note TN00-10. Natick, MA, U.S. Army Research Institute of Environmental Medicine, February 2001.
15. Departments of the Army, the Navy, and the Air Force: Nutrition Allowances and Education. AR 40-25 (Naval Command Medical Instruction 10110.0, Air Force Regulation 160-95). Washington, DC, Headquarters, June 2001.
16. Institute of Medicine: Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids. Washington, DC, National Academy Press, 2002.
17. Burke LM, Cox GR, Cummings NK, Desbrow B: Guidelines for daily carbohydrate intake: do athletes achieve them? Sports Med 2001; 31: 267–99.
18. U.S. Department of Agriculture and U.S. Department of Health and Human Services: Nutrition and Your Health: Dietary Guidelines for Americans, Ed 5th, Home and Garden Bulletin No. 232. Washington, DC, U.S. Government Printing Office, 2000.
19. Institute of Medicine: Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium, and Carotenoids. Washington, DC, National Academy Press, 2000.
20. Institute of Medicine: Dietary Reference Intakes for Thiamin, Riboflavin, Niacin, Vitamin B_6, Folate, Vitamin B_{12}, Pantothenic Acid, Biotin, and Choline. Washington, DC, National Academy Press, 1998.
21. Institute of Medicine: Dietary Reference Intakes for Calcium, Phosphorous, Magnesium, Vitamin D, and Fluoride. Washington, DC, National Academy Press, 1997.
22. Smoak BL, Singh A, Day BA, Norton JP, Kyle SB, Pepper SJ, Deuster PA: Changes in nutrient intakes of conditioned men during a 5-day period of increased physical activity and other stresses. Eur J Appl Physiol 1988; 58: 245–51.
23. Lieberman HR, Falco CM, Slade SS: Carbohydrate administration during a day of sustained aerobic activity improves vigilance, as assessed by a novel ambulatory monitoring device, and mood. Am J Clin Nutr 2002; 76: 120–7.
24. Willett W: Nutritional Epidemiology, Ed 2. New York, Oxford University Press, 1998.
25. Coward-McKenzie D, Johnson R: Analysis, presentation, and interpretation of dietary data. In: Nutrition in the Prevention and Treatment of Disease, pp 69–79. Edited by Coulston AM, Rock CL, Monsen ER. San Diego, Academic Press, 2001.
26. Briefel RR, Sempos CT, McDowell MA, Chien SCY, Alaimo K: Dietary methods research in the third National Health and Nutrition Examination Survey: underreporting of energy intake. Am J Clin Nutr 1997; 65(Suppl): 1203S–9S.